THE ADJUSTMENT TO THE BAROMETER OF THE HEMATO-RESPIRATORY FUNCTIONS IN MAN

BY YANDELL HENDERSON

YALE UNIVERSITY MEDICAL SCHOOL

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It is well known that persons living at considerable elevations—such as Colorado, the cities in the Andes, et cetera—exhibit distinct functional adjustments. The amount of hemoglobin per unit volume of blood is increased, and a larger volume of air is breathed per unit mass of oxygen absorbed and CO_2 eliminated.

These are functional adjustments and not merely immediate compensations; for they are developed slowly through days or weeks, and the functions return to sea level values only very gradually. Thus, to illustrate by a single simple test, a man on Pike's Peak, who is acclimated to the altitude, can hold his breath for a much shorter time than when living at sea level. But on descending from the Peak, and during the first few hours thereafter, he can hold it scarcely longer than at the summit.

There is clear evidence that this condition and the increase of breathing are due to a decreased amount of alkali, chiefly $NaHCO_3$, in the blood.

By the now well-known equation of L. J. Henderson,

$$\frac{H_2CO_3}{NaHCO_3} \times K = C_H,$$

it is evident that, if respiration is to maintain the same C_H in the blood at an altitude that it does at sea level, the amount of CO_2 in solution in the blood must be reduced in proportion to the alkali. This is accomplished by an inversely proportional alteration, that is, an increase, of breathing.

It is generally supposed that under oxygen deficiency acids are produced in the tissues and retained in the blood, and that the alkali is thus neutralized and then eliminated through the urine.

Experiments on dogs by Dr. H. W. Haggard and myself, however, show that the processes involved are in many respects exactly the opposite of this supposition. Our experiments demonstrate that, before any considerable amount of alkali is lost, an abnormally large amount of CO_2 is eliminated by the excessive breathing induced by a lowered oxygen pressure in the air breathed. Then alkali passes out of the blood to compensate this alkalosis.

Thus the process is exactly the opposite of that occurring in other experiments which we have performed, in which acid was administered intravenously, and in which, therefore, the alkali was lowered first and the CO_2 in solution was lowered only secondarily.[1] Under low oxygen the lowering of the dissolved $CO_2(H_2CO_3)$ is primary, and that of the alkali secondary.

From these facts and from closely similar observations on aviators[2] during the war, it appears highly probable that in normal persons the blood alkali is controlled by the dissolved CO_2: more or less alkali being called into use in the blood to satisfy the equation above quoted, and to keep the C_H of the blood constant. The amount of dissolved CO_2 in the blood is controlled by the pulmonary ventilation; and fundamentally the ventilation is adjusted to the oxygen partial pressure of the air at the altitude at which the person lives.

Thus, as data from the report of the Pike's Peak expedition[3] tend to confirm, the partial pressure of oxygen in the lungs, the alveolar CO_2, the $CO_2(H_2CO_3)$ dissolved in the blood, and the amount of the blood alkali (the so-called "alkaline reserve"), each multiplied by a constant of its own, tend to vary in direct proportion to the mean barometer, minus the water vapor tension of the pulmonary air (about 45 mm.) at all altitudes.

[1] Haggard, H. W., and Henderson, Yandell, *J. Biol. Chem.*, **39**, No. 1, August, 1919 (163–261).

[2] Henderson, Yandell, *Science, New York*, N. S., **49**, No. 1271, May 9, 1919 (431–441).

[3] Douglas, Haldane, Henderson, and Schneider, *London Phil. Trans. Roy. Soc.*, B. **203**, 1913 (310).

A STUDY OF ABSORPTION SPECTRA WITH THE ELECTRIC FURNACE

BY ARTHUR S. KING

MOUNT WILSON OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

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The tube resistance furnace has found a place as a useful light-source in spectroscopic work, but thus far it has been used mainly for the production of emission spectra. The long column of vapor, whose temperature can be controlled, offers interesting possibilities, however, in the field of absorption phenomena. In the experiments to be described, the continuous background was supplied by a plug of graphite placed in the center of the furnace tube, the heated portion of which was 20 cm. long and 12.5 mm. internal diameter. A close approach to black-body conditions is thus obtained, and the emission of the plugged tube is stronger than that of the metallic vapor filling the tube. An absorption spectrum results, which, by simply removing the plug, may be compared with the emission spectrum given by the vapor at the same temperature.

It is known from observations of reversed emission lines that in a given range of spectrum, some lines are more subject to reversal than others. The present experiments have shown this to result from a close connection between the tendency of a line to reverse and the two factors which enter into the classification of lines in furnace spectra, viz., the temperature at which a line is first radiated and its response to increase of temperature.